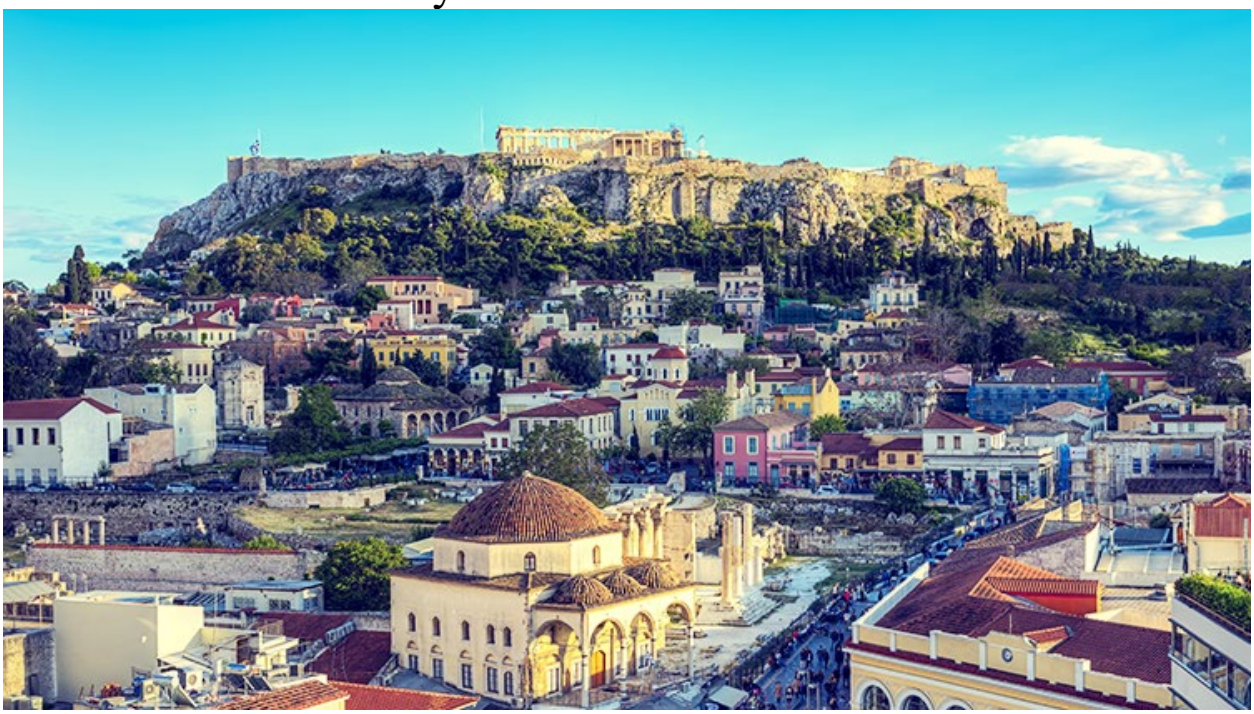
IAQ 2020: Indoor Environmental Quality Performance Approaches

Transitioning from IAQ to IEQ

May 4th - May 6th, 2022
Athens, Greece
Wyndham Grand Athens



Preliminary Technical Program

A Hybrid Conference with Livestreamed Sessions and Keynotes
Conference includes 120+ papers, 4 Workshops and Live, Virtual-Only Sessions
www.ashrae.org/IAQ2020

Updated: April 28, 2022

Wednesday, May 4

Wednesday, May 4, 9:30 AM - 10:15 AM

Keynote 1 (Intermediate)

LIVESTREAM: 20-Year Update on ASHRAE's Adaptive Thermal Comfort Model

Room: Zeus (Lower Level)

Chair: Richard de Dear, The University of Sydney, Australia, Sydney, Australia, Bjarne Olesen, Technical University of Denmark, Lyngby, Denmark

ASHRAE's TC 2.1, Physiology and Human Environment, published its adaptive thermal comfort model (RP-884), which went on to become part of ASHRAE Standard 55, Thermal Environmental Conditions for Human Occupancy in 2004. A 2018 update and expansion of the RP-884 global thermal comfort database prompted a rigorous quality assurance exercise on the first-generation adaptive comfort standards. Comfort questionnaire records validated ASHRAE Standard 55's adaptive comfort model for naturally ventilated premises. Data supported developing a mixed mode adaptive model closely aligned to the naturally ventilated counterpart, contradicting Standard 55's treatment of mixed mode buildings as the same as conventionally air-conditioned buildings.

20-Year Update on ASHRAE's Adaptive Thermal Comfort Model

***Richard de Dear**, The University of Sydney, Australia, Sydney, Australia*

Wednesday, May 4, 10:15 AM - 11:00 AM

Keynote 2 (Intermediate)

LIVESTREAM: Overview of the Health Effects of Light in the Built Environment: More than Just Vision

Room: Zeus (Lower Level)

Chair: Mariana Figuiero, Ph.D., Icahn School of Medicine at Mount Sinai, New York, NY, Marianna Vallejo, PhD, Jacobs, Portland, OR

Biological rhythms that repeat approximately every 24 hours are called circadian rhythms. If lack of synchrony or circadian disruption occurs, we may experience decrements in physiological functions, neurobehavioral performance and sleep. Lighting characteristics affecting the circadian system are different than those affecting vision, and yet, all lighting standards and metrics are based on visibility. Data from laboratory investigations how circadian-effective light can improve sleep, mood and behavior is presented. This presentation discusses what lighting changes are needed in the built environment to promote health and well-being.

Overview of the Health Effects of Light in the Built Environment: More Than Just Vision

***Mariana Figuiero, Ph.D.**, Icahn School of Medicine at Mount Sinai, New York, NY*

Wednesday, May 4, 11:15 AM - 12:45 PM

Conference Paper Session (Intermediate)

Ventilation Session 1

Room: Athena 1 (1st Level)

Chair: Willem de Gids, VentGuide, Amsterdam, Netherlands

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Developing a New Passive Tracer Gas Test to Measure Total Air Change Rate (C1142)

***Sarah Paralovo**[1], Marianne Stranger[2], Maarten Spruyt[2], Joris Lauwers[2], Rudi Swinnen[2], Borislav Lazarov[2] and Jelle Laverge, Member[3], (1)UGent, Ghent, Belgium, (2)VITO, Belgium, (3)Ghent University, Gent, Belgium*

Experimental Quantification of Air Volume Flow By Natural Ventilation through Window Opening (C1179)

***Jun Jiang**, Jingxin Yang, Kai Rewitz, Dr.Ing. and Dirk Müller, Dr.Ing., Institute for Energy Efficient Buildings and Indoor Climate, E.ON Energy Research Center, RWTH Aachen University, Aachen, Germany*

Indoor Environmental Quality Assessment: Ventilation Systems with Different Types of Linear Diffusers (C11452)

*Marek Borowski[1], **Klaudia Zwolińska**[2] and Joanna Halibart[1], (1)AGH University of Science and Technology, Poland, (2)AGH University of Science and Technology, Kraków, Poland*

Numerical Evaluations of a Multiple 3D Particle Tracking Velocimetry System for Indoor Airflow Study (C1273)

*Masoumeh Nedaei[1], **Pascal Biwole, Ph.D.**[2], Eric Dekneuvel[3] and Gilles Jacquemod[3], (1)Université Clermont Auvergne, France, (2)Université Clermont Auvergne, Clermont-Ferrand, France, (3)Université Côte d'Azur, France*

Effect of Design Parameters on Indoor Temperature Distribution in Impinging Jet Ventilated Room (C1274)

Haruna Yamasawa, Ph.D.[1], *Tomohiro Kobayashi, Ph.D.*[2], *Toshio Yamanaka, Ph.D., Member*[2], *Narae Choi, Ph.D.*[2] *and Mako Matsuzaki*[2], *(1)Kyushu University, Fukuoka, Japan, (2)Osaka University, Osaka, Japan*

11:15 AM - 12:45 PM

Conference Paper Session (Intermediate)

Smart Controls, Smart Sensors and Big Data Session 1

Room: Athena 2 (1st Level)
Chair: Iain Walker, Ph.D., Fellow ASHRAE, Lawrence Berkeley National Laboratory, Berkeley, CA

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Sensor Location Scheme for Improved IEQ Monitoring in Working Environments (C11469)
Salam Chaker Al Samman, Ph.D., Student Member*, Loughborough University, Loughborough, United Kingdom*

Implementation of Predictive Control for an All-Air Ventilation System in an Educational Building (C1160)
Bart Merema[1], *Dirk Saelens*[2] *and* ***Hilde Breesch***[3], *(1)KU Leuven, Belgium, (2)KU Leuven, Heverlee, Belgium, (3)KU Leuven, Leuven, Belgium*

Simulation Case Study on Outdoor Air Quality Demand Controlled Ventilation (C1288)
Klaas De Jonge, CEng, Student Member[1] *and Jelle Laverge, Member*[2], *(1)Ghent University, Ghent, Belgium, (2)Ghent University, Gent, Belgium*

11:15 AM - 12:45 PM

Conference Paper Session (Intermediate)

LIVESTREAM: Thermal Comfort Session 1

Room: Zeus (Lower Level)
Chair: Carsten Rode, Ph.D., Member, Technical University of Denmark, Kgs. Lyngby, Denmark

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Assessing the Overall Indoor Environmental Comfort and Satisfaction: Evaluation of a Questionnaire Proposal By Means of Statistical Analysis of Responses (C1326)
Ilaria Pittana[1], *Federica Morandi*[2], *Francesca Cappelletti, Ph.D.*[3], *Andrea Gasparella*[2] *and Athanasios Tzempelikos, Ph.D., Member*[4], *(1)University of Padua, Italy, (2)Free University of Bozen-Bolzano, Italy, (3)Iuav University of Venice, Venice, Italy, (4)Purdue University, West Lafayette, IN*

Study on Indoor Environment and Learning Efficiency (C1111)
Kohei Onishi *and Ryoichi Kuwahara, Yamaguchi University, Japan*

Evaluation of Indoor Environment Subjective Perception in Large Office Building (C1307)
Zuzana Veverkova *and Karel Kabele, CTU in Prague, Czech Republic*

Tracking Occupant Satisfaction for Improved Energy Efficiency in Campus Buildings (C1407)
Yewande Sonayon Abraham, Ph.D., Associate Member[1] *and Rosaria Elisabeth Cardoso Amaral*[2], *(1)Rochester Institute of Technology, Rochester, NY, (2)Rochester Institute of Technology*

Do Spatially Distributed Sensor Measurements Provide Better Representation of Indoor Environment than Single Sensor Measurements? A Mechanically Ventilated Office Space Case Study (C1132)
Donya Sheikh Khan, Ph.D.[1], *Jakub Kolarik, Ph.D.*[2], *Christian Hviid*[3] *and Peter Weitzmann*[4], *(1)Ramboll, Copenhagen, Denmark, (2)Technical University of Denmark, Kgs. Lyngby, Denmark, (3)Technical University of Denmark, Denmark, (4)NCC Denmark, Denmark*

Wednesday, May 4, 1:45 PM - 2:30 PM

Keynote 3 (Intermediate)

LIVESTREAM: Controlling Infection Risk through Healthcare

Room: Zeus (Lower Level)
Chair: Catherine J. Noakes, Ph.D., University of Leeds, Leeds, United Kingdom, Arnold Janssens, Ph.D., Member, Ghent University, Gent, Belgium

Design transmission of infection is conventionally regarded as either a human behaviour or a medical challenge, yet the environment can also significantly influence this process. This is particularly the case for airborne transmission of infection, where the physical passage of microorganisms in the air depends on the airflow in building design, and their survival depends on environmental conditions. This talk considers the engineering and modelling strategies that can be used to understand the mechanisms for airborne infection and to evaluate the effectiveness of design solutions.

Controlling Infection Risk through Healthcare
***Catherine J. Noakes, Ph.D.**, University of Leeds, Leeds, United Kingdom*

Wednesday, May 4, 2:45 PM - 4:15 PM

Conference Paper Session (Intermediate)

Interactions Between IEQ Parameters Session 1

Room: Athena 2 (1st Level)
Chair: Jelle Laverge, Member, Ghent University, Gent, Belgium

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The Effects of HVAC System Design on Moderating Infectious Pathogen Spread in Healthcare Environments (C1346)
***Ryan Sharston**, University of Florida, FL*

Coupling Air Multi-Zone and Thermal Multi-Zone Models in Modelica (C1277)
***Josué Borrajo Bastero**[1], Jelle Laverge, Member[2], Marc Delghust[2], Elisa Van Kenhove[3] and Matthias Van Hove[3], (1)Ghent University, Ghent, Belgium, (2)Ghent University, Gent, Belgium, (3)Ghent University, Belgium*

The Influence of Balconies on the Indoor Environmental Conditions of Dwellings (C1195)
***Catarina Ribeiro**[1], Pedro F. Pereira[1], Nuno M. Ramos[1], Inês Flores-Colen[2] and Nuno Valentim[3], (1)Faculdade de Engenharia da Universidade do Porto, Portugal, (2)Universidade de Lisboa, Portugal, (3)Faculdade de Arquitectura da Universidade do Porto, Portugal*

Comparison between Key Species Simulated Using the Simplified Indoor Air Chemistry Simulator Model and Previously Published Values from Reference Models (A1310)
***Nicole K. Scharko**, Serena H. Chung, Jordan Zambrana, Daniel Malashock and Vito Ilacqua, U.S. Environmental Protection Agency*

2:45 PM - 4:15 PM

Conference Paper Session (Intermediate)

VIRTUAL: Disaster and Pandemic Resilience and IEQ

Room: HERA 1
Chair: Chandra Sekhar, Ph.D., Fellow ASHRAE, National University of Singapore, Singapore, Singapore

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Assessment of the COVID-19 Contagion Risk in University Classrooms with TRNSYS and TRNFLOW Simulations (C11509)
***Riccardo Albertin**[1], Giovanni Pernigotto, Ph.D.[1] and Andrea Gasparella[2], (1)Free University of Bozen-Bolzano, Bolzano, Italy, (2)Free University of Bozen-Bolzano, Italy*

Examination of Occupant Arrangement in an Office Floor Based on Nonuniformity of CO2 Concentration Using Computational Fluid Dynamics Simulation (C11466)
***Rina Hirai, Student Member**[1], Yasunori Akashi[2] and Shohei Miyata[2], (1)The University of Tokyo, Tokyo, Japan, (2)The University of Tokyo, Japan*

Numerical Analysis of Airflow Dynamics Generated by Human Coughing Based on PIV Experimental Results (C11477)
***Wonseok Oh**[1], Ryozo Ooka, Ph.D., Member[1], Hideki Kikumoto, Ph.D., BEAP[2] and Mengtao Han[2], (1)The University of Tokyo, Japan, (2)The University of Tokyo, Tokyo, Japan*

Thermal Comfort and Indoor Environment with Wearing a Mask (C11489)
***Motoki Kondo** and Sihwan Lee, Shinshu University, Japan*

Ventilation and Indoor Thermal Environment in Air-Conditioned Rooms with Open Windows in Winter (C11491)
***Akira Okamura** and Sihwan Lee, Shinshu University, Japan*

2:45 PM - 4:15 PM

Conference Paper Session (Intermediate)

LIVESTREAM: Disaster and Pandemic Resilience and IEQ Session 1

Room: Zeus (Lower Level)
Chair: Karel Kabele, Dr.Ing., Member, REHVA, Prague, Czech Republic, Sonia Garcia-Ortega, Eduardo Torroja Institute for construction sciences - CSIC, Madrid, Spain

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Measurements of Exhaled Airflow Velocity Via Human Coughs Using Particle Image Velocimetry (C11457)
Mengtao Han[1], *Ryozo Ooka, Ph.D., Member*[2], *Hideki Kikumoto, Ph.D., BEAP*[3], *Wonseok Oh*[2], *Yunchen Bu*[3] *and Shuyuan Hu*[2], *(1)Huazhong University of Science and Technology, Wuhan, China, (2)The University of Tokyo, Japan, (3)The University of Tokyo, Tokyo, Japan*

Experimental Study of Exhaust Air Transfer Ratio in a Rotary Heat Recovery Ventilation Unit with Automatic Leakage Control (C11518)
Lei Fang, Ph.D., Member[1], *Bjarne Olesen*[1], *Henning Groenbaek*[2] *and Daniel Kampgaard Munck*[2], *(1)Technical University of Denmark, Lyngby, Denmark, (2)EXHAUSTO*

CFD Modeling of Room Air Flow Effects on Inactivation of Aerosol SARS-CoV-2 by an Upper Room Ultraviolet Germicidal Irradiation System (C11497)
Youngbo Won, Student Member[1], *Donghyun Rim, Associate Member*[1], *Richard Mistrick*[2] *and* ***William Bahnfleth, Ph.D., P.E., Presidential Fellow ASHRAE***[1], *(1)Pennsylvania State University, University Park, PA, (2)Pennsylvania State University, PA*

Indoor Environmental Quality Performance Approaches: Trending from IAQ to IEQ Related to COVID-19 (A11458)
Shannon Horn, P.Eng., BCxP, Member[1], *Shelly Miller, Member*[2], *Matthew Mcqueen*[2] *and Timothy Lockhart*[2], *(1)University of Colorado at Boulder Facilities Engineering, Boulder, CO, (2)University of Colorado at Boulder, Boulder, CO*

2:45 PM - 4:15 PM

Workshop 1 (Intermediate)

NZEB Residential Retrofit and Environmental Quality: Results from the ReCO2ST Project

Room: Athena 1 (1st Level)
Chair: Maria Kolokotroni, Brunel University London, Uxbridge, United Kingdom

The ReCO2ST project focuses on residential retrofit for near zero energy and CO2 emissions with optimum cost, health, comfort and environmental quality. It includes the development of an assessment platform, and selected technologies implemented to four demonstration buildings in Europe (Denmark, Switzerland, Spain and the UK). The project was completed in December 2021. This workshop presents results focusing on environmental quality improvement in the retrofit of buildings.

On The Impact Of Highly Reflective Materials In Thermal Comfort And Energy Efficiency
Elisavet Tsekeri[1], *Angeliki Mavrigiannaki*[2], *Konstantinos Gobakis*[2], *Dimitrios Xilas*[2], *Dionysia Kolokotsa*[2], *Maria Kolokotroni*[3] *and Francisco Jose Sánchez De La Flor*[4], *(1)Technical University of Crete, Crete, Greece, (2)Technical University of Crete, Greece, (3)Brunel University London, Uxbridge, United Kingdom, (4)University of Cadiz, Spain*

RECO2ST Project: On the Holistic Approach Considering Both Energy, IEQ and Environment
Per Heiselberg, *Aalborg University, Aalborg, Denmark*

Bio-Technical Air-Treatment Systems
Heinz Gattringer, *alchemia-nova GmbH, Vienna, Austria*

Bio-Technical Air-Treatment Systems
Nerina Efthymiou-Charalampopoulou, *Alchemia Nova, Vienna, Austria*

Air Quality and Draft Risks Tested for 4 Air Inlet Strategies with Demand Control Extract Ventilation: In-Situ Tests on the ReCO2st Swiss Case Study after NZEB Refurbishment
Flourentzos Flourentzou, *ESTIA, Lausanne, Switzerland*

Smart Window with an Air-Based Solar Thermal Collector and PCM Solar Energy Storage: Energy Aspects As Well As Possibility to Reduce the Risk of Draft and Control IAQ
Per Heiselberg, *Aalborg University, Aalborg, Denmark*

Paper # 2296 -- On the Impact of Highly Reflective Materials on Thermal Comfort and Energy Efficiency
Elisavet Tsekeri, *Technical University of Crete, Crete, Greece*

Wednesday, May 4, 4:30 PM - 6:00 PM

Conference Paper Session (Intermediate)

Air Tightness Session 1

Room: Athena 1 (1st Level)
Chair: Adeline Melois, Cerema, Bron Cedex, France

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High-Rise Buildings Airtightness Measurements: Practical Advices and Error Estimation (C11443)
*Nolwenn Hurel[1] and **Valérie Leprince, Ph.D.**[2], (1)PLEIAQ, France, (2)PLEIAQ, Meyzieu, France*

Impact of Building Airtightness on Heat Generator and Heat Emission Equipment Sizing (C1353)
***Sebastien Pecceu** and Paul Van Den Bossche, Belgian Building Research Institute, Belgium*

Three-Dimensional Characterization of the Air Infiltration Path Using Infrared Technology (C1163)
*Raquel Gil-Valverde, Diego Tamayo-Alonso, Andrés Royuela-Del-Val, **Irene Poza-Casado**, Héctor Jimeno-Merino, Alberto Meiss, Miguel Ángel Padilla-Marcos and Jesús Feijó-Muñoz, Universidad de Valladolid, Spain*

Using Adjacent Unit Pressures to Compute Exterior Leakage from Compartmentalization Tests (C1316)
***David Bohac, P.E., Member**[1], Collin Olson[2], Gary Nelson[2] and Bob Davis, Associate Member[3], (1)Center for Energy and Environment, (2)The Energy Conservatory, (3)Ecotope*

Reducing Wind Sensitivity for Blower Door Testing (C1133)
***Benedikt Kölsch**[1] and Iain Walker, Ph.D., Fellow ASHRAE[2], (1)German Aerospace Center (DLR), Jülich, Germany, (2)Lawrence Berkeley National Laboratory, Berkeley, CA*

4:30 PM - 6:00 PM

Conference Paper Session (Intermediate)

VIRTUAL: Performance Metrics

Room: HERA 1
Chair: Atila Novoselac, Ph.D., Associate Member, The University of Texas at Austin, Austin, TX, Richard Mistrick, The Pennsylvania State University, University Park, PA

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Indoor Conditions in Educational Buildings: The Case of Bolzano Schools (C1301)
*Simone Dugaria[1], **Giovanni Pernigotto, Ph.D.**[2] and Andrea Gasparella[1], (1)Free University of Bozen-Bolzano, Italy, (2)Free University of Bozen-Bolzano, Bolzano, Italy*

BIM-Integrated Indoor Aerosol Modeling Based on Outdoor Particles in Germany (C1202)
***Jan Drzymalla, Student Member**[1], Jannick Höper[2], Sven Eckers[3], Sebastian Theissen[2], Michaela Lambertz[2] and Andreas Henne[2], (1)University of Applied Sciences (TH Köln), Cologne, Germany, (2)TH KölnGermany, Germany, (3)Weber & Partner, Germany*

CFD Simulations of an Aerosol Chamber for Calibration of Low-Cost Particulate Matter Sensors (C1205)
***Jan Drzymalla, Student Member**[1], Yannic Lay[2], Marc Sauermann[2] and Andreas Henne[2], (1)University of Applied Sciences (TH Köln), Cologne, Germany, (2)TH KölnGermany, Germany*

Modelling the Similarity and the Potential of VOC and Moisture Buffering Capacities of Hemp Concrete on Indoor Air Quality and Relative Humidity (C1393)
***Anh Dung Tran Le**[1], Jianshun S Zhang[2], Zhenlei Liu[2], Driss Samri[3] and Thierry Langlet[4], (1)University of Picardie Jules Verne, Amiens, France, (2)Syracuse University, Syracuse, NY, (3)Centre Scientifique et Technique du Bâtiment, France, (4)University of Picardie Jules Verne, France*

A Study of Daylight Modeling Approaches Applied in LEED (C11454)
***Maryam Esmailian**, Richard Mistrick, Ute Poerschke and Lisa Iulo, The Pennsylvania State University, University Park, PA*

4:30 PM - 6:00 PM

Conference Paper Session (Intermediate)

LIVESTREAM: Interactions Between IEQ Parameters Session 2

Room: Zeus (Lower Level)
Chair: Georgi Ivanov Popov, Ph.D., University of Central Missouri, Warrensburg, MO, James McGrath, Ph.D., National University of Ireland, Galway, Galway, Ireland

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Applying NABERS IE to a University Building in the UK (C1279)
***Paul Ajiboye**[1], Vyt Garnys[1] and Glyn Cash[2], (1)CETEC, (2)Leeds Beckett University*

Understanding the Effects of Environmental Factors on Human Perception By Means of Surveys and in Field Measurements (C1278)
*Ilaria Pittana[1], Federica Morandi[2], **Francesca Cappelletti, Ph.D.**[3], Andrea Gasparella[2] and Athanasios Tzempelikos, Ph.D., Member[4], (1)University of Padova, Italy, (2)Free University of Bozen-Bolzano, Italy, (3)Iuav University of Venice, Venice, Italy, (4)Purdue University, West Lafayette, IN*

Low-Energy Retrofitted Homes from Their Occupants' Perspectives: Indoor Environmental Quality and Satisfaction with Heating and Mechanical Ventilation Systems (C1283)
*Lucile Sarran[1], **Carsten Rode, Ph.D., Member**[2] and Christian Anker Hviid[3], (1)Technical University of Denmark, Kongens Lyngby, Denmark, (2)Technical University of Denmark, Kgs. Lyngby, Denmark, (3)Technical University of Denmark, Denmark*

IAQ-Prediction In Multi-Zone Reduced Order BES-Models (C1312)
***Matthias Yvan C. Van Hove**[1], Josué Borrajo Bastero[2], Elisa Van Kenhove[1], Marc Delghust[3] and Jelle Laverge, Member[3], (1)Ghent University, Belgium, (2)Ghent University, Ghent, Belgium, (3)Ghent University, Gent, Belgium*

Informing Indoor Environmental Parameters: Analyzing Measures of Microbial Ecology with Respect to the Characterization of Indoor Air Quality (C11513)
***Phoebe Mankiewicz**[1], Christina Ciardullo[1], Andreas Theodoridis[2], Elizabeth Henaff[3] and Anna Dyson[1], (1)Yale Center for Ecosystems in Architecture, New Haven, CT, USA, New Haven, CT, (2)Rensselaer Polytechnic Institute Center for Architecture, Troy, NY, (3)New York University Tandon School of Engineering, New York, NY*

Thursday, May 5

Thursday, May 5, 8:30 AM - 9:15 AM
Keynote 4 (Intermediate)

LIVESTREAM: The Acceptability of Air Quality in Domestic Kitchens

Room: Zeus (Lower Level)
Chair: Benjamin Jones, Ph.D., University of Nottingham, Nottingham, United Kingdom, Maria Kapsalaki, INIVE, Brussels, Belgium

Cooking food is a primary source of fine particulate matter (PM2.5), acrolein, and NO2 in non-smoking homes, which are associated with elevated risks of acute and chronic health effects. Health impact studies show that PM2.5 is the most dangerous indoor pollutant. This talk will consider two methods for measuring uncertainty in cooking PM2.5 emission rates and use them to evaluate three ventilation strategies commonly used in domestic kitchens. It intends to show that standards should be amended to incorporate required combinations of airflow rates and cooker hood capture efficiencies, and to consider methods of measuring cooker hood capture efficiency.

The Acceptability of Air Quality in Domestic Kitchens
***Benjamin Jones, Ph.D.**, University of Nottingham, Nottingham, United Kingdom*

Thursday, May 5, 9:30 AM - 11:00 AM
Conference Paper Session (Intermediate)

Smart Controls, Smart Sensors and Big Data Session 2

Room: Athena 1 (1st Level)
Chair: Bjarne W. Olesen, Ph.D., Fellow ASHRAE, Intl. Center for Indoor Environment and Energy, Technical University of Denmark, Lyngby, Denmark

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Automated Fault Detection Strategy on Virtual In-Situ Calibration Building Energy System: Partition of Calibration Domain (C1246)
***Peng Wang, Ph.D.**[1], Jiteng Li[1], Sungmin Yoon[2], Tianyi Zhao[1] and Yuebin Yu, Ph.D., Associate Member[3], (1)Dalian University of Technology, (2)Incheon National University, Republic of Korea, (3)University of Nebraska-Lincoln, Omaha, NE*

IEQ Direct Reading Instruments: Myths and Realities (C1121)
***Georgi Ivanov Popov, Ph.D.**[1] and Tsvetan Ivanov Popov[2], (1)University of Central Missouri, Warrensburg, MO, (2)University of Central Missouri*

Suitability of Low-Cost Particulate Matter Sensors for Measurements in Ventilation Systems (C1162)
*Jesus Marval[1], Luis Medina[2], **Paolo Tronville, Ph.D., Fellow ASHRAE**[3] and Juan Vallejo[1], (1)Politecnico di Torino - DENERG, Italy, (2)Politecnico di Torino - DENERG, (3)Politecnico di Torino - DENERG, Turin, Italy*

Machine Learning for Occupancy Detection through Smart Home Sensor Data (C1177)
Sundaravelpandian Singaravel[1], *Steven Delrue*[1], *Ivan Pollet, Dr.Ing.*[2] *and Steven Vandekerckhove*[1], *(1)Renson, Belgium, (2)Renson, Waregem, Belgium*

SMART-RENO-IEQ: Exploring the Capabilities of Low-Cost Sensors to Evaluate PM2.5 Exposure in Single-Family Houses (C11461)
Charles-Florian Picard[1], *Jordan Litaud*[2], *Adrien Dhalluin*[2], *Jérôme Nicolle*[3], *Bénédicte Wall-Ribot*[4], *Karim Limam*[5] *and Marc Abadie*[5], *(1)La Rochelle Université, La Rochelle, France, (2)TIPEE platform, France, (3)TIPEE Platform, France, (4)EDF Lab Les Renardières, Ecuelles – Moret-Loing-et-Orvanne, France, (5)La Rochelle Université, France*

9:30 AM - 11:00 AM

Conference Paper Session (Intermediate)

LIVESTREAM: Ventilation Session 2

Room: Zeus (Lower Level)
Chair: Gaëlle Guyot, Ph.D., Member, CEREMA, Bron Cedex, France, Pilar Linares Alemparte, IETCC, CSIC, Madrid, Spain

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Agreement In Radon Variability Between Proximate Houses (A1292)
Zachary Merrin, Member[1], ***Paul Francisco, Fellow ASHRAE***[2] *and Stacy Gloss*[3], *(1)University of Illinois, (2)University of Illinois, Champaign, (3)University of Illinois, United States of America*

Ambient Air Pollution Influence on Natural Ventilation Potential (A11456)
Evangelos Belias, Student Member[1] *and Dusan Licina, Ph.D., Associate Member*[2], *(1)École Polytechnique Fédérale de Lausanne, Lausanne, Switzerland, (2)École Polytechnique Fédérale de Lausanne, Switzerland*

Investigating Uncertainty in Relationship Between Indoor Steady State CO2 Concentrations and Ventilation Rates (C1138)
Constanza Molina, Ph.D.[1], *Benjamin Jones, Ph.D.*[2] *and Andrew Persily, Ph.D., Fellow Life Member*[3], *(1)Pontificia Universidad Católica de Chile, Santiago, Chile, (2)University of Nottingham, United Kingdom, (3)National Institute of Standards and Technology, Gaithersburg, MD*

IEA EBC Annex 68: Ambitions and Achievements in Hindsight (C1329)
Carsten Rode, Ph.D., Member[1], *Marc Abadie*[2], *Pawel Wargocki, Ph.D., Associate Member*[3], *Menghao Qin*[4], *John Grunewald*[5], *Jianshun {Jensen} Zhang*[6], *Jakub Kolarik, Ph.D.*[1], *Jelle Laverge, Member*[7] *and Fitsum Tariku, Member*[8], *(1)Technical University of Denmark, Kgs. Lyngby, Denmark, (2)La Rochelle Université, (3)Technical University of Denmark, Kongens Lyngby, Denmark, (4)Technical University of Denmark, Denmark, (5)Technische Universität Dresden, (6)Syracuse University, (7)Ghent University, Gent, Belgium, (8)British Columbia Institute of Technology, Burnaby, BC, Canada*

Analysis of Potential Impacts of Policy Options for Inspections of Stand-Alone Ventilation Systems in EU Dwellings (C1373)
Arnold Janssens, Ph.D., Member[1], *Yanaika Decorte*[1], *François Durier*[2] *and Peter Wouters*[3], *(1)Ghent University, Gent, Belgium, (2)INIVE-CETIAT, Villeurbanne, France, (3)INIVE-BBRI, Brussels, Belgium*

9:30 AM - 11:00 AM

Conference Paper Session (Intermediate)

IAQ Assessment Session 1

Room: Athena 2 (1st Level)
Chair: Maria Kolokotroni, Brunel University London, Uxbridge, United Kingdom

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Ventilation Effectiveness of Alternating Façade-Integrated Ventilation Devices in a Dwelling (C1146)
Sven Auerswald*, Raghavakrishna Devineni, Thibault Pflug and Constanze Bongs, Fraunhofer Institute for Solar Energy Systems ISE, Germany*

A Holistic Approach to Indoor Environmental Quality Assessment (C1217)
Alex Reese Mavrelis[1] *and John Earman*[2], *(1)Gallagher Bassett Services, Inc., (2)EE&G Restoration Services, LLC*

Assessing Thermal Resilience to Overheating in an Office Building (C1154)
Abantika Sengupta[1], *Jonas Deleu*[2], *Brecht Lucidarme*[2], *Marijke Steeman*[3] *and Hilde Breesch*[4], *(1)KU Leuven, Gent, Belgium, (2)KU Leuven, (3)Ghent University, Belgium, (4)KU Leuven, Leuven, Belgium*

Indoor Air, Ventilation and Comfort in Irish Domestic Dwellings Post Deep Energy reNovations-ARDEN (A1424)
Nina Wemken[1], ***Marie Coggins, Ph.D.***[2], *Brian Mcintyre*[3], *Conor Hanniffy*[3], *Bourdin Emmanuel*[1] *and Asit Kumar Mishra*[1], *(1)National University of Ireland Galway, Ireland, (2)National University of Ireland Galway, Galway, Ireland, (3)Deep Retrofit Pilot Programme, Ireland*

Exploring the Relationship between Indoor Air Quality and Climate Change in Residential Buildings, Part A: Developed Measurement Devices of Low-Cost Sensors (C11484)
S. Mohsen Pourkiaei *and Anne-Claude Romain, University of Liege, Belgium*

9:30 AM - 11:00 AM

Conference Paper Session

VIRTUAL: IEQ Assessment

Room: HERA 1
Chair: Alireza Afshari, Aalborg University, Copenhagen, Denmark

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Indoor Environmental Quality in Schools in South Tyrol: Insights from the Field Measurements, and on the Initial Design of the Improvements (C1387)
Francesco Babich, Ph.D., Associate Member[1]*, Annamaria Belleri, Ph.D.*[1]*, Ingrid Demanega*[2]*, Clara Peretti*[3]*, Luca Verdi*[3] *and Gianmaria Fulici*[3]*, (1)Eurac Research, Bolzano, Italy, (2)Eurac Research, Italy, (3)Provincia Autonoma Bolzano, Italy*

A Practical Comparison of Capture Efficiencies under Real Conditions and by Applying the ASTM Standard: An Experimental Assessment (C1309)
Hyusan Jang[1]*, Seongjun Park*[2]*, Shinhye Lee*[3]*, Hyunsoo Kim*[4]*, Seungkil Son*[4]*, Dong Hwa Kang*[5]*, Donghyun Rim, Associate Member*[6] *and Myoung Souk Yeo, Ph.D., Member*[3]*, (1)Seoul National University, Seoul City, Republic of Korea, (2)Pennsylvania State University, (3)Seoul National University, Republic of Korea, (4)Kyungdong Navien Co., Ltd, Republic of Korea, (5)University of Seoul, Republic of Korea, (6)Pennsylvania State University, University Park, PA*

Evolving Frameworks Towards Identifying Challenges and Opportunities of Indoor Vegetation Systems (C11514)
Christina Ciardullo[1]*, Andreas Theodoridis*[2]*, Phoebe Mankiewicz*[1]*, Naomi Keena*[1] *and Anna Dyson*[1]*, (1)Yale Center for Ecosystems in Architecture, New Haven, CT, USA, New Haven, CT, (2)Rensselaer Polytechnic Institute Center for Architecture, Troy, NY*

A Numerical Study of the Effect of Limited Space Air Stability on SARS-CoV-2 Spreading in a Ventilated Room (C11464)
Xiaorui Deng[1] *and Guangcai Gong*[2]*, (1)Hunan University, Changsha, China, (2)Hunan University, China*

Energy poverty map: Online Survey System of the Indoor Environmental Quality for Energy Poverty in South Korea (C11485)
Jong-Won Lee*, Korea Institute of Civil Engineering and Building Technology, Goyang-si, Gyeonggi-do, Republic of Korea*

Thursday, May 5, 11:15 AM - 12:45 PM

Conference Paper Session (Intermediate)

VIRTUAL: Health and Well-Being

Room: HERA 1
Chair: Hiroshi Yoshino, Ph.D., Fellow ASHRAE, Tohoku University, Sendai, Japan, Takao Sawachi, Ph.D., NILIM, Tsukuba, Japan

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Defining Health: Update from ASHRAE SGPC 10 Committee, Interactions Affecting the Achievement of Acceptable Indoor Environments (C1335)
Carl Grimes, Member[1]*, Frederick Marks, AIA*[2] *and Mark Cree Jackson*[3]*, (1)Hayward Healthy Home Institute, Monterey, CA, (2)Salk Institute for Biological Studies, (3)Daikin North America LLC*

Experimental Measurements of Particles and CO2 Exhaled By a Manikin in a Hospital Room (C1161)
Inés Olmedo, Ph.D.[1]*, Fernando Peci, Ph.D.*[1]*, Jose Luis Sanchez*[2] *and* ***Manuel Ruiz De Adana Sr., Ph.D., Member***[3]*, (1)University of Córdoba, Córdoba, Spain, (2)University of Cordoba, Spain, (3)University of Cordoba, Cordoba, Spain*

Health Canada's Indoor Air Program: Risk Assessment and Research to Support Standards Development (C1135)
Jocelyn Moore, Ph.D.[1]*, Francis Lavoie*[2] *and Katherine Guindon-Kezis*[2]*, (1)Health Canada, Ottawa, ON, Canada, (2)Health Canada, Canada*

Indoor Environmental Quality and its Effects on Human Sleep Quality (C11446)
Hagen Earl Fritz*, Kerry Kinney, Ph.D., David Schnyer, Ph.D. and Zoltan Nagy, Ph.D., Associate Member, University of Texas at Austin, Austin, TX*

Study on Indoor Environment and Elderly's Health in China (A1374)
Hiroshi Yoshino, Ph.D., Fellow ASHRAE[1]*, Tomonobu Goto*[2]*, Gaston Song*[2]*, Zhenhai Li*[3]*, Nianping Li*[4]*, Jing Liu*[5]*, Jingchao Xie*[6]*, Huibo Zhang*[7]*, Yang Lv*[8] *and Jun Guan*[9]*, (1)Tohoku University, Sendai, Japan, (2)Tohoku University, Japan, (3)Tongji University, (4)Hunan University, (5)Harbin Institute of Technology, (6)Beijing University of Technology, (7)Shanghai Jiao Tong University, (8)Dailian University of Technology, (9)Nanjing University of Science and Technology*

11:15 AM - 12:45 PM

Conference Paper Session (Intermediate)

LIVESTREAM: Occupant Behavior/Policy and Standards Session 1

Room: Zeus (Lower Level)
Chair: Donald Weekes, InAir Environmental Ltd, Ottawa, ON, Canada, Jaap Hogeling, Dr.Ing., Fellow ASHRAE, ISSO, Rotterdam, Netherlands

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Impact of WELL Building Standard v2 on the Office Building Energy Performance (C1182)
Jiannan Luo[1], *Ines Idzikowski*[2] *and Anis Abou Zaki*[2], *(1)Foster + Partners, London, United Kingdom, (2)Foster + Partners, United Kingdom*

Implementation of a User Feedback System and Its Impact on User Satisfaction and Energy Demand (C1176)
Felix Nienaber[1], ***Alexander Kümpel***[1], *Kai Rewitz, Dr.Ing.*[1] *and Dirk Müller, Dr.Ing.*[2], *(1)RWTH Aachen University, Germany, (2)RWTH Aachen University, Aachen, Germany*

Untold Stories from the Field: A Novel Platform for Collecting Practical Learnings on Human-Building Interactions (C11492)
Carola Lingua[1], ***Connor Brackley, Student Member***[2], *Giorgia Spigliantini*[1], *Helen Stopps, Student Member*[3], *June Young Park*[4], *Karol Bandurski*[5], *Lucile Sarran*[6], *Maíra André*[7], *Sarah Crosby*[8], *Stephanie Gauthier*[9] *and Yuzhen Peng*[10], *(1)Politecnico di Torino, Italy, (2)Concordia University, Montreal, QC, Canada, (3)University of Toronto, Toronto, ON, Canada, (4)University of Texas Arlington, (5)Poznán University of Technology, Poland, (6)Technical University of Denmark, Kongens Lyngby, Denmark, (7)Federal University of Santa Catarina, Brasil, (8)University of British Columbia, Canada, (9)Southampton University, United Kingdom, (10)ETH Zürich, Switzerland*

ASHRAE's Residential IAQ Guide: Practical Guidance for Home Builders and Occupants (C1319)
Lawrence Schoen, P.E., Fellow ASHRAE[1], *Terry Brennan*[2] *and Amy Musser, P.E., CPMP, BEMP and BEAP, Member*[3], *(1)Schoen Engineering Inc, Columbia, MD, (2)Camroden Associates, Inc., Westmoreland, NY, (3)Vandemusser Design, PLLC, Asheville, NC*

11:15 AM - 12:45 PM

Workshop 2 (Intermediate)

Ventilative Cooling to Reduce Overheating in Buildings to Achieve Good Well-Being: Framing, New Design Approaches and Cases - It Works!

Room: Athena 1 (1st Level)
Chair: Christoffer Plesner, VELUX A/S, Hørsholm, Denmark and Jannick Roth, WindowMaster International A/S, Vedbæk, Denmark

This workshop focuses on ventilative cooling – why this topic is important and showing documented case studies. New developments are revealed with the latest on the implementation of ventilative cooling in international standards, findings of recently finished research projects, etc. Further, the workshop highlights what to be aware of in order to get a well-performing ventilative cooling system in your building and some recommendations to go along with this.

Introduction
Jannick Roth, *WindowMaster International A/S, Vedbæk, Denmark*

Introduction to Ventilative Cooling and Its Relevance
Per Heiselberg, *Aalborg University, Aalborg, Denmark*

Upcoming European and International Technical Documents on "Ventilative Cooling Systems - Design" in CEN/ISO
Christoffer Plesner, *VELUX A/S, Hørsholm, Denmark*

Introduction to the International Venticool Platform and the IEA EBC Annex 62 Deliverables
Hilde Breesch, *KU Leuven, Leuven, Belgium*

Danish Design Guide on "Ventilative Cooling" for Natural Ventilative Cooling: Example from a Danish Residential Building in Ry
Per Heiselberg, *Aalborg University, Aalborg, Denmark*

Standardization of an Evaluation Methodology for Natural Ventilative Cooling Potential in Early Stage Design of Buildings
Annamaria Belleri, Ph.D., *Eurac Research, Bolzano, Italy*

Night Cooling as a Ventilative Cooling Solution for a Belgian Residential Building
Hilde Breesch, *KU Leuven, Leuven, Belgium*

Danish Office Buildings
Jannick Roth, *WindowMaster International A/S, Vedbæk, Denmark*

11:15 AM - 12:45 PM

Workshop 3 (Intermediate)

Better Quantifying and Locating Building Leakages

Room: Athena 2 (1st Level)

Sponsor: TightVent/AIVC

Chair: Valérie Leprince, Ph.D., PLEIAQ, Meyzieu, France

Air infiltration has multiple consequences on energy use and IEQ that depend on the location and distribution of leakage. Among other, pollutant infiltration and air draft are highly impacted by leakage distribution. In current practice, leakage detection is often performed together with airtightness test. However, a recent study (Moujalled et al., 2019) showed that airtightness level was not correlated with the number of leaks detected through visual assessment. This stresses the need for methods quantifying leakage through building components. Such methods would help contractors to assess the quality of on-site execution.

Detection of Air Leakage in Building Envelopes using Microphone Arrays

Benedikt Kölsch[1]*, Björn Schiricke*[1]*, Eckhard Lüpfert*[2] *and Bernhard Hoffschmidt*[1]*, (1)German Aerospace Center (DLR), Jülich, Germany, (2)German Aerospace Center (DLR), Germany*

Introduction on the Need of Methods for Quantifying Leakages of Building Components and Short Review of Existing Method

Valérie Leprince, Ph.D.*, PLEIAQ, Meyzieu, France*

Measurement of Installed Window Airtightness

Bassam Moujalled*, CEREMA, Bron, France*

Potential of Non-Invasive MEMS Pressure Sensors for Measuring Building Envelope Air

Mark Modera, Ph.D., P.E., Fellow ASHRAE*, University of California, Davis, CA*

Thursday, May 5, 1:45 PM - 2:30 PM

Keynote 5 (Intermediate)

LIVESTREAM: All You Need to Know about the Indoor Environment, its Occupants and Interactions

Room: Zeus (Lower Level)

Chair: Philomena Bluyssen, Ph.D., Delft University of Technology, Faculty of Architecture and the Built Environment, Delft, Netherlands, Arnold Janssens, Ph.D., Member, Ghent University, Gent, Belgium

Research shows that, even when conditions comply with current standards for indoor environmental quality (IEQ), staying indoors is not good for our health. IEQ is described with quantitative dose-related indicators, expressed in numbers and/or ranges of numbers for each of the factors. Stressors and factors are rarely considered. Lack of knowledge combined with improper use of available data hampers creating a healthy and comfortable indoor environment. The SenseLab has been created to facilitate the understanding of the indoor environment, and it allows students, teachers, researchers, and the general public to experience and test different combinations of environmental conditions.

All You Need to Know about IEQ and the SenseLab

Philomena Bluyssen, Ph.D.*, Delft University of Technology, Faculty of Architecture and the Built Environment, Delft, Netherlands*

Thursday, May 5, 2:45 PM - 4:15 PM

Conference Paper Session (Intermediate)

Thermal Comfort Session 2

Room: Athena 1 (1st Level)

Chair: Constantinos Balaras, Ph.D., Fellow ASHRAE, National Observatory of Athens (NOA), Athens, Greece

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Predicting Older People's Thermal Sensation by a New Integrated Physiological-Based and Data-Driven Model (C11506)

Lili Ji[1]*, Chang Shu*[2]*, Abdelaziz Laouadi*[3]*, Liangzhu Wang*[4] *and Michael Lacasse*[3]*, (1)Concordia University, Montreal, QC, Canada, (2)Concordia University, Canada, (3)National Research Council Canada, Ottawa, Canada, (4)Concordia University, Montréal, QC, Canada*

Fan-Assisted Trench Heating in Extreme Outdoor Temperatures (C1249)

Olga Yakimchuk*, APEX Project Bureau, Moscow, Russian Federation*

IEQ Assessment in free-running University Classrooms (C1173)

Giannis Papadopoulos, Student Member*, Evangelos I. Tolis and Giorgos Panaras, University of Western Macedonia, Kozani, Greece*

2:45 PM - 4:15 PM

Conference Paper Session (Intermediate)

VIRTUAL: Interactions Between IEQ Parameters

Room: HERA 1

Chair: Arnold Janssens, Ph.D., Member, Ghent University, Gent, Belgium

.

Simulating Ventilation for Indoor Air Quality of Non-Domestic Environments in London Schools: A Building-Based Bottom-Up Approach (C1401)

Shih-Che Hsu, Ph.D.[1], *Ian Hamilton*[2], *Anna Mavrogianni*[3] *and Rob Liddiard*[2], *(1)UCL Energy Institute, London, United Kingdom, (2)UCL Energy Institute, United Kingdom, (3)UCL Institute for Environmental Design and Engineering, United Kingdom*

Integrating Indoor Soundscape Approach into IEQ Research: Acoustic Comfort in Naturally Ventilated Residential Buildings (C1125)

Simone Torresin, Dr.Eng[1], *Rossano Albatici*[2], *Francesco Aletta*[3], *Francesco Babich, Ph.D., Associate Member*[1], *Tin Oberman*[3] *and Jian Kang*[3], *(1)Eurac Research, Bolzano, Italy, (2)University of Trento, (3)University College London, United Kingdom*

Moisture Control in Indoor Environments: When Hygric Inertia May Contribute to Deliver Better Comfort Conditions (C1172)

Stefano Zanon *and Rossano Albatici, University of Trento, Italy*

Design of a Ventilation System to Improve IAQ and Thermal Comfort in a Textile Factory (C11472)

Bernard Anders Djapermal *and Santaram Venkannah, University of Mauritius, Mauritius*

Balancing Reductions in Exposure to VOCs and their Secondary Products Indoors vs. the Infiltration of Outdoor Pollutants (A1270)

Jordan Zambrana*, Nicole Scharko, Serena Chung, Daniel Malashock and Vito Ilacqua, U.S. Environmental Protection Agency*

2:45 PM - 4:15 PM

Conference Paper Session (Intermediate)

LIVESTREAM: Smart Controls, Smart Sensors and Big Data Session 3

Room: Zeus (Lower Level)

Chair: Bassam Moujalled, CEREMA, Bron, France, Marc Abadie, Ph.D., Université de La Rochelle, La Rochelle, France

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Energy Efficient Smart IAQ Management for Residential Buildings (C1372)

Jelle Laverge, Member*, Ghent University, Gent, Belgium*

Low Relative Humidity, a Problem or Not in Swedish Dwellings? (A1369)

Theofanis Psomas[1], *Despoina Teli*[2], *Sarka Langer, Ph.D.*[2] *and Paula Wahlgren, Ph.D.*[1], *(1)Chalmers University of Technology, Gothenburg, Sweden, (2)Chalmers University of Technology, Sweden*

Monitoring Indoor Environmental Quality in Buildings with Wireless Distributed Sensing Network (C11502)

Joshua Vasudevan[1], *Daniel Coakley, Ph.D., Associate Member*[2], *Charalampos Angelopoulos*[2], *Parag Rastogi, Ph.D., Member*[3], *Olivia Nile Sobek, Ph.D.*[4] *and Graeme Jephson*[4], *(1)Loughborough University, United Kingdom, (2)Mitsubishi Electric R&D Centre, United Kingdom, (3)Arbnco Ltd, Glasgow, United Kingdom, (4)Arbnco Ltd, United Kingdom*

Performance Analysis of the Maximal Used Extract Ventilation Capacity of Dwellings During the Heating Season (C1253)

Ivan Pollet, Dr.Ing.[1], *Bavo De Maré*[2], *Frederik Losfeld*[2], *Steven Delrue*[3], *Steven Vandekerckhove*[3] *and Jelle Laverge, Member*[4], *(1)Renson, Waregem, Belgium, (2)Renson Ventilation, Belgium, (3)KU Leuven, Belgium, (4)Ghent University, Gent, Belgium*

Smart Ventilation Performance Durability Assessment: Preliminary Results from a Long-Term Residential Monitoring of Humidity-Based Demand-Controlled Ventilation (C1264)

Sandrine Charrier[1], *Elsa Jardinier*[2], *François Parsy*[2], *Stéphane Berthin*[2], *Elise Hallemans*[1], *Emmanuel Roux*[1] *and Gaëlle Guyot, Ph.D., Member*[3], *(1)Cerema, France, (2)AERECO, France, (3)CEREMA, Bron Cedex, France*

Thursday, May 5, 4:30 PM - 6:00 PM

Conference Paper Session (Intermediate)

Ventilation Session 3

Room: Athena 1 (1st Level)
Chair: François Durier, INIVE-CETIAT, Villeurbanne, France

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Assessment of the Performance of Hybrid Ventilation System: Case Study of a Multi-Family Building in France (C1247)
Bassam Moujalled[1], *Gabriel Remion*[2], *Romuald Jobert, Ph.D.*[2], *Anissia Benzekhroufa*[3], *Claire-Sophie Coeudevez*[3], *Marc Dufresne*[4], *François Demouge*[4] *and Corinne Mandin*[5], *(1)CEREMA, Bron, France, (2)CEREMA, France, (3)MEDIECO, France, (4)CSTB, France, (5)CSTB, Marne-la-Vallée, France*

Breathing: A New High Efficient Ventilation Concept for Non-Residential Buildings (C1104)
Ralf Wagner, Member*, LTG Aktiengesellschaft, Stuttgart, Germany*

Restriction of Air Infiltration By an Air Curtain Optimized with Secondary Jets: A Numerical Investigation (C1120)
Claudio Alanis Ruiz, Dr.Eng[1], *Twan Van Hooff*[2], *Bert Blocken*[3] *and GertJan Van Heijst*[2], *(1)Department of Civil Engineering, KU Leuven, Leuven, Belgium, (2)Eindhoven University of Technology, Netherlands, (3)Eindhoven University of Technology, Eindhoven, Netherlands*

Ventilation Benefit when Using Radiative Cooling Material in High Ambient Temperature Countries (C1115)
Walid Chakroun, Ph.D., Fellow ASHRAE[1], *Sorour Alotaibi, Ph.D., Associate Member*[2], *Nesreen Ghaddar, Ph.D., Member*[3] *and Kamel Ghali, Ph.D.*[3], *(1)Kuwait University, kuwait, Kuwait, (2)Kuwait University, Kuwait, Kuwait, (3)American University of Beirut, Beirut, Lebanon*

Case Study: Heat Recovery and Demand Controlled Ventilation In Industrial Kitchens and Behavior of Occupants (C1245)
A.Tayfun Sumbul, P.Eng., Member[1] *and Faruk Cimen*[2], *(1)Fair Mekanik Mühendislik Ltd.Sti, Ankara, Turkey, (2)Untes Klima A.S., Turkey*

4:30 PM - 6:00 PM

Conference Paper Session (Intermediate)

LIVESTREAM: Air Tightness Session 2

Room: Zeus (Lower Level)
Chair: Wouter Borsboom, TNO, Delft, Netherlands, Arnold Janssens, Ph.D., Member, Ghent University, Gent, Belgium

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Airtightness of Buildings: Assessment of Leakage-Infiltration Ratio and Systematic Measurement Error Due to Steady Wind and Stack Effect (C11442)
Christophe Y. M. Delmotte*, Belgian Building Research Institute, Bruxelles, Belgium*

Assessment of Wind Impact on Building Air Leakage Measurements Using a Model Scale Experiment (C11462)
Adeline Melois[1], *Mohamed El Mankibi*[2], *Francois Rémi Carrié*[3] *and Bassam Moujalled*[4], *(1)Cerema, Bron Cedex, France, (2)ENTPE, France, (3)ICEE, France, (4)CEREMA, Bron, France*

Exterior and Total Envelope Leakage of New U.S. Low-Rise Multifamily Buildings (C1218)
David Bohac, P.E., Member[1], *Russ Landry*[1], *Lauren Sweeney*[1], *Bob Davis, Associate Member*[2] *and Scott Pigg*[3], *(1)Center for Energy and Environment, (2)Ecotope, (3)Slipstream*

Comparison of Airflow and Acoustic Measurements for Evaluation of Building Air Leakage Paths in a Laboratory Test Apparatus (C1134)
Benedikt Kölsch[1], *Iain Walker, Ph.D., Fellow ASHRAE*[2], *Woody Delp, Ph.D.*[2], *Björn Schiricke*[1] *and Bernhard Hoffschmidt*[1], *(1)German Aerospace Center (DLR), Jülich, Germany, (2)Lawrence Berkeley National Laboratory, Berkeley, CA*

Impact of Precautionary Measures on Indoor Radon Levels in Retrofit Homes (A1311)
Stacy Lynn Lynn Gloss[1], ***Paul Francisco, Fellow ASHRAE***[1], *Sherry Dixon*[2], *Jonathan Wilson*[2], *Zachary Merrin, Member*[1], *Jill Breysse*[2], *Yigang Sun*[1] *and Jingwei Su*[1], *(1)University of Illinois, (2)National Center for Healthy Housing*

4:30 PM - 6:00 PM

Conference Paper Session

VIRTUAL: Interactions Between IEQ Parameters, Smart Controls, Smart Sensors, and Big Data

Room: HERA 1
Chair: Andrew Persily, Ph.D., Fellow Life Member, NIST, Gaithersburg, MD

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A Programmable Image Sensor for Smart Daylighting and Glare Control in Buildings (A1323)
*Michael Kim, Ph.D., Student Member[1], Iason Konstantzos, Ph.D., Member[2] and **Athanasios Tzempelikos, Ph.D., Member**[1], (1)Purdue University, West Lafayette, IN, (2)University of Nebraska-Lincoln, Omaha, NE*

New Low-Cost Sensing Network for Indoor Environmental Monitoring and Control in Buildings (A1320)
*Michael Kim, Ph.D., Student Member[1], Hejia Zhang[1], **Athanasios Tzempelikos, Ph.D., Member**[1], Andrea Gasparella[2] and Francesca Cappelletti, Ph.D.[3], (1)Purdue University, West Lafayette, IN, (2)Free University of Bozen-Bolzano, Italy, (3)Iuav University of Venice, Venice, Italy*

Applicability of a Residential CO2-Controlled Energy Recovery Ventilator for Varying Occupancy: Application to a Bedroom with Simulated Occupancies (C1299)
***Boualem Ouazia Sr., Ph.D., Member**[1], Chantal Arsenault[2], Gang Nong[3], Mark Vuotari[1] and Daniel Sanders[4], (1)National Research Council Canada, Ottawa, ON, Canada, (2)National Research Council Canada, Ottawa, Ontario, Canada, (3)National Research Council Canada, Canada, (4)Carleton Univeristy*

Understanding and Estimating Patients' Indoor Environmental Quality Assessment: A Pilot Case Study in a Hospital Ward (C1200)
***Sara Willems**[1], Dirk Saelens[2] and Ann Heylighen[1], (1)KU Leuven, Leuven, Belgium, (2)KU Leuven, Heverlee, Belgium*

Analysis and Optimisation of Building Efficiencies through Data Analytics and Machine Learning (C1306)
***Ryan Grammenos**[1], Konstantinos Karagiannis[2] and Manuel Escalante Ruiz[1], (1)University College London, United Kingdom, (2)General Techonology Ltd., Greece*

Friday, May 6

Friday, May 6, 8:30 AM - 9:15 AM

Keynote 6 (Intermediate)

LIVESTREAM: New Research Reveals the Power of Indoor Air Management to Improve Human Health

Room: Zeus (Lower Level)
Chair: Stephanie Taylor, M.D., Member, Building 4 Health, Inc., Stowe, VT, Shelly Miller, Member, University of Colorado at Boulder, Boulder, CO

A perplexing and costly rise in infection and chronic disease challenges us to understand hidden factors at play. Understanding how the indoor environment influences acute and chronic diseases has lagged behind other research. However, with new genetic analysis tools, our understanding of indoor communities of viruses, bacteria, and fungal organisms improves rapidly. We are learning that indoor air management in mechanically ventilated buildings selects the bacteria and viruses that cause disease, while simultaneously weakening the human immune system. While alarming, this also reveals a new, powerful strategy to curtail viral and bacterial epidemics.

New Research Reveals the Power of Indoor Air Management to Improve Human Health
***Stephanie Taylor, M.D., Member**, Building 4 Health, Inc., Stowe, VT*

Friday, May 6, 9:30 AM - 10:45 AM

Conference Paper Session (Intermediate)

Smart Controls, Smart Sensors and Big Data Paper Session 4

Room: Athena 1 (1st Level)
Chair: Ivan Pollet, Dr.Ing., Renson, Waregem, Belgium

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Analysis of Zoned Residential Ventilation Controls (C1308)
***Iain Walker, Ph.D., Fellow ASHRAE**[1], Brennan Less[2], David Lorenzetti, Ph.D.[2] and Michael Sohn, Ph.D.[2], (1)Lawrence Berkeley National Laboratory, Berkeley, CA, (2)Lawrence Berkeley National Laboratory*

Development of a Smart Thermostat (C1174)
Leonidas Zouloumis, Student Member[1] *and Giorgos Panaras*[2]*, (1)University of Western Macedonia, Kozani, Greece, (2)University of Western Macedonia, Greece*

Validation of a Simplified Model Predictive Control of a Low Exergy Embedded Heating and Cooling System (C11512)
Tor Helge Dokka, Dr.Ing.[1]*, Niels Lassen*[2]*, Thomas Johnsen*[2] *and Helge Koppang*[2]*, (1)Skanska, KONGSBERG, Norway, (2)Skanska, Norway*

9:30 AM - 10:45 AM

Conference Paper Session (Intermediate)

LIVESTREAM: Health and Well-Being Session 1

Room: Zeus (Lower Level)
Chair: Shelly Miller, Member, University of Colorado at Boulder, Boulder, CO, Marie Coggins, Ph.D., National University of Ireland Galway, Galway, Ireland

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Impacts of the Indoor Environment in Our Homes and Schools on Child Health (C1362)
Daniel Gehrt[1]*, Marco Hafner*[1]*, Sune Tobias Grollov*[2] *and* ***Jens Christoffersen, Ph.D.***[3]*, (1)RAND Europe, (2)VELUX A/S, (3)VELUX A/S, Hoersholm, Denmark*

Collecting Long-term Indoor Environmental Quality Data in Highly Energy Efficient Irish Dwellings (A1370)
James Anthony Mcgrath[1]*, James O'Donnell, Ph.D.*[2] *and Miriam Byrne*[1]*, (1)National University of Ireland Galway, Ireland, (2)University College Dublin, Dublin, Ireland*

IAQ Assessment in Higher Education Classrooms with Natural Ventilation during the Cold Season (C1164)
Héctor Jimeno-Merino, ***Irene Poza-Casado****, Raquel Gil-Valverde, Diego Tamayo-Alonso, Andrés Royuela-Del-Val, Alberto Meiss, Miguel Ángel Padilla-Marcos and Jesús Feijó-Muñoz, Universidad de Valladolid, Spain*

IAQ aspects of Daycare Centers: A Systematic Review of Exposure to Particulate Matter (C1112)
Wim Zeiler and ***Hailin Zheng, Student Member****, TU Eindhoven, Eindhoven, Netherlands*

9:30 AM - 10:45 AM

Conference Paper Session

VIRTUAL: Ventilation

Room: HERA 1
Chair: Ulla Haverinen-Shaughnessy, National Institute for Health and Welfare, Kuopio, Finland

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Modeling the Effectiveness of Portable Air Cleaners with Open Windows (A1183)
Vito A Ilacqua*, US EPA*

Constructing a Dual-Index Regulation for the Design of Envelope Performance of Hybrid Ventilated School Building (A1196)
Ai-Wen Huang, Student Member[1]*, Wei-An Chen*[2]*, Ruey-Lung Hwang*[2] *and Kuo-Tsang Huang*[1]*, (1)National Taiwan University, Taipei, Taiwan, China, (2)National Kaohsiung Normal University, Taiwan, China*

Design and Preliminary Test of a Heat Pump-Driven Liquid Desiccant System for a Residential Building (C1240)
Jae-Hee Lee[1]*, Jin-Young Ko*[1] *and Jae-Weon Jeong, Ph.D., Member*[2]*, (1)Hanyang University, Republic of South Korea, (2)Hanyang University, Seoul, Republic of South Korea*

Numerical Analysis on the Applicability of Air Purifier for Removal of Indoor Viral Contaminants (C11488)
Yunchen Bu[1]*, Ryozo Ooka, Ph.D., Member*[2]*, Hideki Kikumoto, Ph.D., BEAP*[1] *and Wonseok Oh*[2]*, (1)The University of Tokyo, Tokyo, Japan, (2)The University of Tokyo, Japan*

9:30 AM - 10:45 AM

Workshop 4 (Intermediate)

Impact of Building and Ductwork Airtightness on IEQ: What Do We Know, What Do We Need?

Room: Athena 2 (1st Level)
Chair: Valérie Leprince, Ph.D., PLEIAQ, Meyzieu, France and Iain Walker, Ph.D., Fellow ASHRAE, Lawrence Berkeley National Laboratory, Berkeley, CA

As discussed in the AIVC Ventilation Information Paper n°37, even if energy remains the main driver to improve building and ductwork airtightness, there are increasing concerns regarding the impact of airtightness on IEQ and on building durability. The

objective of this session is to discuss the research needed in the field of building and ductwork airtightness to have a better view on their impact on indoor environmental quality.

What Do We Know Regarding the Impact of Ductwork Airtightness on IEQ?
***Valérie Leprince, Ph.D.**, PLEIAQ, Meyzieu, France*

Ducts and Soil Contaminants: Evidence from Radon Studies
***Paul Francisco, Fellow ASHRAE**, University of Illinois, Champaign*

Duct Leakage Impacts on IEQ
***Mark Modera, Ph.D., P.E., Fellow ASHRAE**, University of California, Davis, CA*

Friday, May 6, 11:00 AM - 12:30 PM

Conference Paper Session (Intermediate)

Ventilation Session 4

Room: Athena 1 (1st Level)
Chair: Peter Wouters, Ph.D., Member, Belgian Building Research Institute, Brussels, Belgium

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Modeling Contaminant Transport from Garage to Living Space in Residential Buildings Based on Single Tracer Gas Decay Measurements (C1304)
*Yigang Sun[1], **Paul Francisco, Fellow ASHRAE**[2] and Zachary Merrin, Member[1], (1)University of Illinois at Urbana Champaign, (2)University of Illinois, Champaign*

Ventilation for Energy Efficiency and Improved Indoor Environmental Quality and Health in University Classrooms (A1282)
***Sangeetha Kumar, Student Member**, Kate Gayler, Grace Madigan, Annette Nguyen and Atila Novoselac, Ph.D., Associate Member, The University of Texas at Austin, Austin, TX*

Ammonia Removal Performance of Desiccant Wheel in a Clean Air Heat Pump (A1113)
*Ying Sheng[1] and **Lei Fang, Ph.D., Member**[2], (1)Tianjin University, Tianjin, Tianjin, China, (2)Technical University of Denmark, Lyngby, Denmark*

Open or Closed? Use of Windows and Internal Doors at Home: Experienced Ventilation Rates and Indoor Air Quality in Dwellings (C1297)
***Jessica Few** and Clifford Elwell, University College London, United Kingdom*

Impact of the Overall Heat Loads on the Performance of the Operating Room Ventilation System: A Numerical Study (C1313)
***Parastoo Sadeghian, Ph.D.**[1], Cong Wang[2] and Sasan Sadrizadeh[1], (1)KTH Royal Institute of Technology, Stockholm, Sweden, (2)KTH Royal Institute of Technology, Sweden*

11:00 AM - 12:30 PM

Conference Paper Session (Intermediate)

LIVESTREAM: Performance Metrics Session 1

Room: Zeus (Lower Level)
Chair: Benjamin Jones, Ph.D., University of Nottingham, Nottingham, United Kingdom, Constanza Molina, Ph.D., Pontificia Universidad Católica de Chile, Santiago, Chile

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Metrics on Perception, Concentration and Characterization of Indoor Air Quality in a University Library (C1300)
*Giobertti Raul Morantes Quintana[1], Gladys Rincon Polo[2] and **Benjamin Jones, Ph.D.**[3], (1)Universidad Simon Bolivar, Venezuela, (2)ESPOL, Ecuador, (3)University of Nottingham, United Kingdom*

Development of Performance-Based Assessment Methods for Conventional and Smart Ventilation in Residential Buildings (C1267)
*Baptiste Poirier[1], **Gaëlle Guyot, Ph.D., Member**[2] and Monika Woloszyn[3], (1)CEREMA, France, (2)CEREMA, Bron Cedex, France, (3)Univ. Savoie Mont Blanc, France*

Development of a PM2.5 Index Adapted to Short-Term Measurements to Provide Real Time Information to Residential Building Occupants (C1155)
*Mikael Brunet[1], Jérôme Nicolle[2] and **Marc Abadie, Ph.D.**[3], (1)Université de La Rochelle, France, (2)TIPEE Platform, France, (3)Université de La Rochelle, La Rochelle, France*

Design of a Retrospective Survey for Occupant Satisfaction with IEQ in Classrooms (C11487)
***Quinten Carton**[1], Hilde Breesch[2] and Jakub Kolarik, Ph.D.[3], (1)KU Leuven, Ghent, Belgium, (2)KU Leuven, Leuven, Belgium, (3)Technical University of Denmark, Kgs. Lyngby, Denmark*

Relevance of CO2-Based IAQ Indicators: Lessons from a Long-Term Monitoring of Three Positive and Nearly Zero Energy Houses (C11459)
Maria Jose Rueda Lopez[1], *Evelyne Gonze, Ph.D., P.E.*[2], *Gaëlle Guyot, Ph.D., Member*[2], *Michel Ondarts*[2], *Benjamin Golly*[2] *and Frédéric Wurtz*[3], *(1)Univ. Grenoble Alpes, Grenoble, France, (2)Université Savoie Mont Blanc, France, (3)Univ. Grenoble Alpes, France*

11:00 AM - 12:30 PM

Conference Paper Session (Intermediate)

VIRTUAL: Thermal Comfort

Room: HERA 1
Chair: Alireza Afshari, Aalborg University, Copenhagen, Denmark
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Effect on Thermal Comfort and Energy Consumption of Different Installation Height and Supply Air Angle of Room Air Conditioner by Simulation (C1366)
Zixu Yang[1], *Baolong Wang*[2], *Wenxing Shi*[2] *and Xianting Li*[1], *(1)Tsinghua University, Beijing, China, (2)Tsinghua University, China*

Experimental Study of Cool Roof Impact on Building Thermal Performance in Hot-Dry and Dusty Climates (C1152)
Salem A. Algarni*, King Khalid University, Saudi Arabia*

Improved Thermal Comfort in Cabin Aircraft with in-Seat Microclimate Conditioning Module (C1365)
Mathieu LE CAM, Ph.D.[1], *Tejaswinee Darure, Ph.D.*[1] *and Mateusz Pawlucki*[2], *(1)Collins Aerospace | Applied Research & Technology, Cork, Ireland, (2)Collins Aerospace | Global Engineering Center, Wroclaw, Poland*

Performance of Roofs Integrated with Phase Change Materials for Reduction the Cooling Load and Overheating Severity in Hybrid Ventilated Classroom, Taiwan (A1197)
Bi-Lian Chen *and Ruey-Lung Hwang, National Kaohsiung Normal University, Taiwan, China*